

DETERMINING PERSONNEL PROMOTION POLICIES IN HEI

ROCIO DE LA TORRE*

Department of Management / ETSEIB. Universitat Politcnica de Catalunya
Av. Diagonal 647, 7th floor
Barcelona, 08028, Spain

AMAIA LUSA, MANUEL MATEO AND EL-HOUSSAINE AGHEZZAF

Department of Management / IOC / ETSEIB. Universitat Politcnica de Catalunya
Av. Diagonal 647, 11th floor, Barcelona, 08028, Spain

Department of Management / IOC / ETSEIB. Universitat Politcnica de Catalunya
Av. Diagonal 647, 7th floor, Barcelona, 08028, Spain

Department of Industrial Management. Ghent University
Technologiepark 902, 9052 Zwijnaarde, Belgium

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ABSTRACT. This paper addresses the determination of personnel promotion policies in public Higher Education Institutions (HEI) considering aspects such as workers promotion rules, hiring and laying off, workforce diversity and budget constraints. The problem is formulated as a Mixed Integer Linear Program. The objective of the proposed optimization model is not only expressed in economic terms but also addressing the achievement of a preferable staff composition and service level. The model is formulated generally, hence it can be useful for different types of universities taken into account their specificities and characteristics. Specifically, this paper addresses the problem of finding the relationship between economic resources for workers' promotion and the pursued preferable staff composition. The model is applied to a real case, in which several analyses are performed under different scenarios characterized by possible trends in the available budget and the demand. The analyses are for different workforce structures, which reflect different academic and personnel policies. The results address the performance of the proposed model in achieving the preferable structure and also on how promotions --and associated expenditures--, are for young researchers and experienced personnel according to each considered scenario.

1. Introduction. Investing in the development and promotion of personnel has been a hot topic for High Education Institutions (HEI) as a consequence of the economic crisis. The strategic personnel planning is a fundamental decision in determining the required resources for an organization according to its necessities. An incorrect dimensioning of the workforce (in size and composition) can cause serious problems for universities, which could compromise the generational change, budget and objectives' achievement. That is why it is necessary to establish personnel

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* Corresponding author: R. de la Torre.

promotion policies that are aligned with the long term objectives of the organization. However, an efficient personnel planning is hard to achieve [17], since required resources vary according to the core business and activity of the organization.

HEI are typical service organizations for which the principal resource is a group of highly skilled and difficult to replace professionals. This characteristic (the difficulty for replacing workers) increases the importance of designing and implementing long term personnel policies.

Implementations of strategic personnel planning in service organizations began in early eighties. However, a large majority of HEI adopted strategic planning only in late nineties [19]. Regardless the resistance of universities to start developing and implementing their strategic plans [15], there have been several changes in the regulatory framework of the European universities [2, 28]. These changes are mainly driven by the Bologna process which try to standardize the way European universities work [24]. In this framework, some studies carried out in HEI [20, 5, 27, 1] point that the number of strategic personnel practices is increasing and diversifying. However, authors such as [25, 12, 21, 11] note that there is a noticeable gap between the increasing importance of strategic personnel planning and the actual implementation. Moreover, [4] and [18] indicate that commonly the planning of the staff in universities is in most cases short-sighted and motivated from the necessity of solving punctual problems, or deeply explored for a short period of time only to be abandoned later, without any real effort to assess their actual effectiveness. The lack of a formal procedure related to HEI may cause an excessive cost for the staff; shortages or surpluses of academics with certain expertise in some areas or departments; as well as an inadequate workforce composition.

A strategic personnel plan for service organizations can involve many kind of decisions, such as those related to the number of people to hire, dismiss and promote, and these can be addressed applying a formalized procedure. In periods of scarcity of economic resources, new hiring from the labor market could be much difficult; so, internal personnel promotions become as a principal tool for university managers while determining a strategic workforce plan. Current university promotion system permits to incentive those areas or categories which are interested for their strategic goals [30]. Through personnel promotion, universities could regulate the weight of a certain category as well as incentivize some specific personnel profiles. To the best of our knowledge though, there is not a formalized procedure in literature for managers that considers the internal promotions as a principal aspect for determining the strategic personnel plan for an organization, while this is also determined according to a preferable staff composition, budget and service level over multiple departments with different staff profiles (i.e. categories). Our problem is partially considered in a few papers. For instance, [7] develop a mathematical model for aggregating staff planning of a company taking workers' learning curves, as well as hiring and firing rules into account. However, aspects such as workers' internal promotions and the achievement of a preferable or ideal workforce composition are not considered in their model.

Along the same line, [29] formulate a model addressing hiring and firing rules for workers, but the optimization criteria for staff planning are based on purely economic metrics. As in [7], this paper considers workers' transferring between different units of the organization but with the enhanced complexity of addressing workforce heterogeneity. Workforce heterogeneity for staff planning was also addressed by [3, 6, 13], but at the tactical level (for a short term horizon). Further considering

workforce heterogeneity, [16] and [33] addressed the question of how organizations can function better with highly skilled workers through strategic plans, if workers' training and other business oriented policies were applied.

In the service sector, such as healthcare, some authors also present a methodology based on mathematical programming to plan the workforce. For instance, [32] present a methodology for dealing with the strategic staff planning in a hospital, considering different units, but without taking into account a set of categories per each unit. [14] present a methodology for nurse planning considering the cost as the main optimization criteria, however this research does not include the heterogeneity of the medic staff and others optimization criterion, like the service level.

Anyhow, the problem of determining the staff planning for HEI is treated by few researchers, such as [27, 1, 9]. Only the work of [9] considers the achievement of a preferable staff composition through optimization. In their paper, however, the proportion of people eligible to be promoted is considered as given data, while this research considers that the institution can make this ratio grow by means of strategic actions (such as investing in training and research). Of course including this into consideration makes the problem much harder to solve. However, results obtained are more realistic and have a significant practical value.

[22] state that, especially for HEI, where knowledge is the core of the organization, not only the economic criteria are necessary to be considered for determining the staff composition. For instance, [23] present a review of the major decisions in the strategic capacity planning problem and the main factors that may impact in the decision making process in the manufacturing industry. [31] and [26] proposed a guide for the adoption of strategic planning practices in public service organizations, taking into account aspects such as the personnel organized in units (according to their field of expertise) and their localization.

All of the above mentioned aspects for the determination of strategic capacity planning for universities are developed in this paper. This is supported by the development of a Mixed Integer Linear Programming (MILP) model for dealing with the problem.

The paper is organized as follows: Section 2 describes the problem and the scope of the article; Section 3 includes the description of the mathematical model formulation; Section 4 presents a case study; Section 5 defines the diverse workforce composition models and the considered scenarios for the real data; Section 6 discusses on computational results; and finally the conclusions and proposed further work are offered in Section 7.

2. Problem description and scope of the paper. The strategic capacity planning in a service organization consists in determining the staff composition for the organization for several years ahead. Strategic decisions regarding workforce are mainly related to hiring, firing and promotions. This problem is challenging, in particularly for HEI, because of the several additional restrictions to take into account (i.e. workforce heterogeneity, promotion rules, as well as the achievement of a preferable staff composition, the required service level and the minimum cost as optimization criteria). However, it is necessary to differentiate private from public HEI. Since, and although their categories are the same, they are not governed by the same regulations or the same interests for the promotion of personnel [8]. This is why, given the uniqueness of private HEI (each HEI can regulate its promotion system independently), this study focuses on public HEI. Below, some of these restrictions are briefly introduced.

Determination of the strategic capacity planning is a dynamic problem, as boundary conditions and resources vary over time, thus affecting personnel requirements accordingly (the horizon length is denoted by T). Unlike other organizations, HEI workforce is heterogeneous, i.e. workers have different expertise levels and for different knowledge fields. More precisely, workers are divided into units or departments (the number of units is denoted by U) addressing the different knowledge fields; and for each unit workers are further classified in K different categories with regard of their expertise level.

The type of labor contract and promotion rules vary with personnel category. The two major types of categories are permanent and temporary. In the permanent category, workers sometimes can, in turn, follow two different professional career pathways: the so called contractual pathway (KC) and the public/tenure pathway (KP). Progression in public pathway is harder than in contractual one, since although in both pathways workers can be promoted in case a spot is available in an upper category, the exam is harder in the public pathway. However, in contrast to workers in contractual pathway, workers in public pathway cannot be fired. The temporary categories (KT) are mainly composed by young researchers, less skilled than those in permanent categories. The category group and their respectively tasks are described in Table 1, and Figure 1 shows the academic pathway for those categories described in Table 1.

The type of contract for temporary categories is defined and periodically renewed, often on a yearly basis, provided that the required academic merits are progressively satisfied. Further, salary and productivity are usually different for workers in different categories, besides the cited contract and promotion rules. This adds even more complexity to the problem of strategic capacity planning. With regard to the categories, it is also important to note that their total number organizing personnel can vary from one country to another, but in general, they all concern the aforementioned division or classification in terms of temporary and permanent types. Also, apart from the full time workers building up the abovementioned categories, the institution holds also part time lecturers, hired for teaching purposes. Their proportion in the workforce may be limited by governmental or institution specific laws.

Finally, in HEIs the teaching, research, technology transfer and coordination (management) activities are evaluated and the quantity performed by the academic staff is measured in a quantitative way. But, for capacity planning purposes (which is related to staff planning), only the teaching requirements (and the available hours of the different staff categories for teaching) are considered. However, it is necessary to consider the other three tasks inherent to the university professor (research, technology transfer and coordination) because, among other reasons, not considering them would end up in a workforce composed only by part time lecturers. Workforce could be determined mainly based on available budget and teaching demand, the latter being the principal or core activity for the institution. However, the rest of personnel duties indicated above should be also assigned and performed. Thus, considering the nature of public universities, we intend that, besides the costs and teaching demand, it is necessary to achieve a proper service level and a preferable configuration of a staff composition according to the decision criteria in the strategic staff planning. The strategic planning is addressed here by modeling it by means of an optimization model. Therefore, a dynamic and heterogeneous workforce over a considered time horizon is modeled. The problem aims to configure a

Table 1 List of category groups and their associated tasks.

Category group	Description of workers	Tasks
Full Professor (highest categories within <i>KC</i> and <i>KP</i> groups of categories)	This category is composed by the most skilled and experienced workers. Workers within these categories can perform some managerial tasks in the HEI governor (i.e. dean of the faculty).	i) Lead projects / processes, ii) Conduct research, iii) Provide strategic vision for projects in research and technology transfer, as well as for the strategic objectives for the department, iv) Publish scientific results from research, v) Teach professionals in lower categories, vii) Develop management tasks
Tenured Assistant Professor (within <i>KC</i> group of categories) and Tenured Professor (within <i>KP</i> group of categories).	This group of categories is composed by high experienced workers in all aspects of teaching and research. Workers have also skills in scientific project leading.	i) Lead projects / processes, ii) Conduct research, iii) Publish scientific results from research, iv) Teach professionals in lower categories.
Tenure-track Lecturer (within <i>KT</i> group of categories).	This group of categories is composed by professionals with high capacity for carrying out teaching and research activities, with more expertise and knowledge than those in the categories under <i>KT</i>	i) Collaborate in the management of projects and processes, ii) Execute projects required high degree of specialization, iii) Supervise research, iv) Publish scientific results from research, v) Teach young researchers and pupils.
Assistant Lecturer (within <i>KT</i> group of categories)	This group of categories is composed by workers starting their career; thus, they are still in training processes for teaching and research purposes.	i) Participate in research and technology transfer projects, ii) Execute projects under the advice of colleagues in upper categories, iii) Support teaching activities.

preferable workforce structure, addressing the characteristics and promotional rules for different categories. This preferable staff composition has been designed based on the experience of university workers who have developed throughout their careers all the different tasks, including those related to the university management, regardless of their unit and expertise field. Different workforce structures can prioritize skilled workers with enough expertise to lead technology transfer projects and research teams, or, for instance, hold an important proportion of young researchers, so as to ensure the future sustainability of the organization. The different preferable staff compositions will be defined, specifically, from the desired weight of temporary categories composed by young researchers, or permanent categories at the top of workforce structure.

One of the key strategic decisions so as to achieve the preferable workforce composition in public universities -and thus to fulfill the required objectives in research

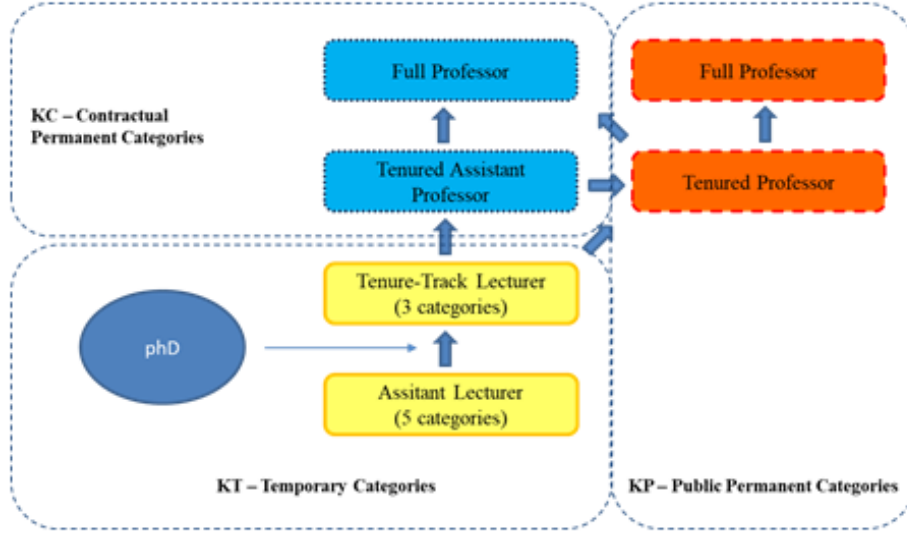


FIGURE 1. Academic pathway

and technology transfer amongst others- is the personnel promotions. In fact, promotions are intended as the first tool for achieving a preferable workforce structure, since decisions on hiring and firing are usually more restrictive and expensive due to their associated costs. For workers, the path through categories is a long process challenged by the need of progressively achieving the required academic merits. To achieve the academic merits for promotion, the institution might provide economic resources or mechanisms. In case the institution does not incur in additional expenditures or economic provisions in personnel budget, and due to the nature of the ordinary tasks deployed by workers, there still exists a certain number of workers that actually can reach the merits to promote. However, this number or proportion of workers can be increased by planning resources for this purpose. These resources can be related with grants, training courses, research and dissemination activities. So, the university can incentivize some knowledge areas or different personnel profile according to their goals. In this paper such economic resources are modelled as a proportion of workers' salaries (we assume that the required merits for promoting are higher with category, and so the associated economic resources). Further details on this are presented in Section 3.

This paper specifically addresses the relationship between the required economic resources needed to transform a certain structural pyramid (in regard of size and composition of workforce) to a preferable one. In particular, focus is on strategic decisions on promotions. Managing promotional ratios (for each category and period) is a way to change the workforce pyramid taking advantage of the existing staff resources. This analysis also considers external factors, such as several trends in demand and available budget. For the sake of clarity, the scope of the paper is graphically depicted in Figure 2.

3. Model formulation. As introduced above, the strategic capacity planning of the institution is obtained as a solution of a Mixed-Integer Linear Program (MILP)



FIGURE 2. Scope of the paper

presented in this section. The formulation has been written in a manner that makes it be applicable to different HEI in any country. For modelling purposes, required data and variables are listed below. Finally, model equations are presented at the end of the section, once all the parameters and the variables are listed.

Data description:

- T Number of periods.
- U Number of units.
- K Number of categories.
- Γ_k^+ Set of categories to which it is possible to access from the category k $[\forall k]$.
- Γ_k^- Set of categories from which it is possible to access to the category k $[\forall k]$.
- c_{kt} Cost in [mu/worker] associated to the category k in period t $[\forall k, t]$.
- ch_{kt} Cost in [mu/worker] associated to hiring a worker for the category k and period t $[\forall k, t]$.
- cf_{kt} Average cost in [mu/worker] associated to firing a worker from the category k in period t $[\forall k, t]$.
- v_t Cost in [mu/hour] associated to outsourcing in period t $[\forall t]$.
- C_{ut} Required teaching hours for the unit u , in period t $[\forall u, t]$.
- h_{kt} Available annual teaching hours (for meeting demand) of workers belonging to category k in period t $[\forall k, t]$.
- L_{ukt} Expected personnel layoffs (for instance, due to retirement or to previously agreed firings) in the unit u , category k , in period t $[\forall u, k, t]$.
- B_t Planned budget for labour costs and part time lecturers for the period t $[\forall t]$.

Parameters associated to the achievement of preferable workforce composition:

- UP_{kt}, LP_{kt} Lower and upper bound for the preferable proportion of workers that belong to the category k in the period t $[\forall k, t]$. These conditions are not hard, but non-compliances are penalized.
- α_{ut} Excess of capacity for teaching hours that should have, at least, the unit u in the period t $[\forall u, t]$. Note that, even if it is not usual, this parameter could be negative if a shortage in the capacity was allowed; this could mean a worsening in the service level (for example, because bigger groups are defined).

- UH_{kt} Upper bound on the number of workers that can be hired from labour market for category k in period t $[\forall k, t]$.
- λ_{kt} Penalty associated to the discrepancy between the preferable and the planned composition of the staff in the category k , in the period t $[\forall k, t]$.
- μ_t Penalty associated to the maximum discrepancy between the preferable and the planned composition of the staff, in the period t $[\forall t]$.
- NR_k Number of possible values for the promotional ratio (r_{ukt}) for category k $[\forall k | \Gamma_k^+ \neq \{\emptyset\}]$.
- vr_{ik} Value of the option number i for the promotional ratio r_{ukt} $[\forall k | \Gamma_k^+ \neq \{\emptyset\}; i=1, \dots, NR_k]$. Note that vr_{1k} would be the proportion of workers from category k that can be promoted if no additional investment in personnel development is planned.
- Δr_k Maximum change of the promotional ratio of category k between two consecutive years $[\forall k | \Gamma_k^+ \neq \{\emptyset\}]$.
- θ_{ik} Required investment in personnel development to achieve the promotional ratio of vr_{ik} $[\forall k | \Gamma_k^+ \neq \{\emptyset\}; i = 1, \dots, NR_k]$. Usually, $\theta_{1k} = 0$.
- NW_k Number of possible values for the number of workers belonging to category k at any unit $[\forall k]$.
- vw_{jk} Value of the option number j for the number of workers belonging to category k at any unit $[\forall k; j = 1, \dots, NW_k]$.

Decision variables for the problem:

- $w_{ukt} \in \mathbb{Z}^+$ Number of workers for unit u , category k and period t $[\forall u, k, t]$.
- $A_{ut} \in \mathbb{R}^+$ Capacity (hours) assigned to part time lecturers in the unit u in period t $[\forall u, t]$.
- $Q_{uklt} \in \mathbb{Z}^+$ Number of workers who access to the category l from the category k , in the unit u , in the period t $[\forall u, t; \forall k | \Gamma_k^+ \neq \{\emptyset\}; \forall l \in \Gamma_k^+]$.
- $w_{ukt}^+ \in \mathbb{Z}^+$ Number of workers who are hired from the labour market for the unit u and category k , in the period t $[\forall u, k, t]$.
- $w_{ukt}^- \in \mathbb{Z}^+$ Number of workers that are dismissed (excluding the previously forecasted) in the unit u and the category k , in the period t $[\forall u, k, t]$.

Other variables:

- D Function of the discrepancy between the preferable and the planned workforce composition.
- $\delta_{kt}^+, \delta_{kt}^- \in \mathbb{R}^+$ Positive and negative discrepancies, respectively, between the preferable and the planned composition of the academic staff in the category k in the period t $[\forall k, t]$.
- $\delta_t \in \mathbb{R}^+$ Maximum discrepancy (positive or negative), between the preferable and the planned composition of the workforce considering all categories in period t (i.e. $\delta_t = \max_k(\delta_{kt}^+, \delta_{kt}^-)$) $[\forall t]$.
- $yrw_{ijuskt} \in (0, 1)$ Boolean variable that equals 1 in the case variables $yr_{iukt} = 1$ and $yw_{juk, t-1} = 1$.
- $yr_{iukt} \in (0, 1)$ Boolean variable that equals 1 in the case that the promotional ratio for category k equals vr_{ik} .
- $yw_{jukt} \in (0, 1)$ Boolean variable that equals 1 in the case $w_{ukt} = vw_{jk}$.

Model:

[MIN] $_Z =$

$$\sum_{\forall u,t} (v_t \cdot A_{ut} + \sum_{\forall k} (c_{kt} \cdot w_{kt} + cf_{kt} \cdot w_{ukt}^- + ch_{kt} \cdot w_{ukt}^+) + \sum_{\forall k | \Gamma_k^+ \neq \{\emptyset\}} \sum_{i=1}^{NR_k} \theta_{ik} \cdot yr_{iukt}) + D \quad (1)$$

Subject to

$$\sum_{\forall k} w_{ukt} \cdot h_{kt} + A_{ut} \geq (1 + \alpha_{ut}) \cdot C_{ut}; \forall u, t \quad (2)$$

$$w_{ukt} = w_{ukt-1} - L_{ukt} + \sum_{s \in \Gamma_k^+} Q_{uskt} - \sum_{l \in \Gamma_k^+} Q_{uklt} + w_{ukt}^+ - w_{ukt}^-; \forall u, k, t \quad (3)$$

$$\sum_{\forall u} w_{ukt}^+ \leq UH_{kt}; \forall k, t \quad (4)$$

$$Q_{uskt} \leq \sum_{i=1}^{NR_k} \sum_{j=1}^{NW_k} vr_{ik} \cdot vw_{jk} \cdot yr_{ijuskt}; \forall u, t; \forall s \in K | \Gamma_s^+ \neq \{\emptyset\}; \forall k \in \Gamma_s^+ \quad (5)$$

$$\sum_{i=1}^{NR_k} yr_{iukt} = 1; \forall u, t; \forall k | \Gamma_k^+ \neq \{\emptyset\} \quad (6)$$

$$\sum_{j=1}^{NW_k} yw_{jukt} = 1; \forall u, k, t \quad (7)$$

$$2 \cdot yr_{ijuskt} \leq yr_{iukt} + yw_{jus,t-1} \leq 1 + yr_{ijuskt}; \quad (8)$$

$$\forall u, t; \forall s | \Gamma_s^+ \neq \{\emptyset\}; \forall k \in \Gamma_s^+; i = 1, \dots, NR_k; j = 1, \dots, NW_k$$

$$w_{ukt} = \sum_{j=1}^{NW_k} vw_{jk} \cdot yw_{jukt}; \forall u, k, t \quad (9)$$

$$\sum_{i=1}^{NR_k} vr_{ik} \cdot yr_{iukt} - \sum_{i=1}^{NR_k} vr_{ik} \cdot yr_{iuk,t-1} \leq \Delta r_k; \forall u, t; \forall k | \Gamma_k^+ \neq \{\emptyset\} \quad (10)$$

$$\sum_{i=1}^{NR_k} vr_{ik} \cdot yr_{iuk,t-1} - \sum_{i=1}^{NR_k} vr_{ik} \cdot yr_{iukt} \leq \Delta r_k; \forall u, t; \forall k | \Gamma_k^+ \neq \{\emptyset\} \quad (11)$$

$$w_{ukt} \geq \left(LP_{kt} \cdot \sum_{\forall k} w_{ukt} \right) - \delta_{kt}^-; \forall u, k, t \quad (12)$$

$$w_{ukt} \leq \left(UP_{kt} \cdot \sum_{\forall k} w_{ukt} \right) + \delta_{kt}^+; \forall u, k, t \quad (13)$$

$$\delta_t \geq \delta_{kt}^+ + \delta_{kt}^-; \forall k, t \quad (14)$$

$$D = \sum_{\forall k,t} [\lambda_{kt} \cdot (\delta_{kt}^+ + \delta_{kt}^-)] + \sum_{\forall t} \mu_t \cdot \delta_t; \forall k, t \quad (15)$$

$$\sum_{\forall u} \left(v_t \cdot A_{ut} + \sum_{\forall k} (c_{kt} \cdot w_{kt}) \right) \leq B_t; \forall t \quad (16)$$

$$w_{ukt}, A_{ut}, Q_{uklt}, w_{ukt}^+, w_{ukt}^-, \delta_{kt}^-, \delta_{kt}^+, \delta_t \geq 0; \forall u, t; \forall k \in K \quad (17)$$

Equation (1) presents the objective function. The aim is to minimize the cost (labour costs, hiring and firing costs and outsourcing cost), plus the investment in personnel development plus a function of the discrepancy between the preferable and

the planned workforce composition. Constraint (2) imposes the minimum available capacity (including outsourced hours) considering the demand and the required service level. Equation (3) is the balance of the number of workers for each category, unit and period, considering all inputs and outputs. Note that, if a category is permanent, then this equation should be modified deleting the term $-w_{ukt}$ in order to not consider firings from that category. The number of workers to be hired is upper bounded by equation (4). Equation (5) limits the number of workers that can be promoted, which is a proportion (that in turn depends on the investment in personnel development) of the workers in that category in previous period. Note that the number of promotionable workers is in fact the result of multiplying two variables so it has been linearised by using binary variables. Equations (6) and (7) force that only one of the possible values for promotional ratios and number of workers, respectively, is selected. Equation (8) include the relation between the binary variables used to linearise the upper bound on the promotions. Equation (9) includes the relation between the number of workers and the corresponding binary variables and possible values (this variable has been discretized to linearise the product of the number of workers by the promotional ratio). Equations (10) and (11) limit, for each category, the change in the promotional ratio between two consecutive periods.

Equations (12) and (13) express the relation between the composition of the workforce, the preferable composition, and the discrepancy variables; then, Equation (14) calculates the maximum discrepancy, for each period and within all categories, to avoid, as much as possible, that the discrepancy is concentrated in few categories (assuming that it is preferable a regular distribution of the discrepancy).

Equation (15) expresses the value of the variable D variable (which is one of the criteria included in the objective function) as a function of the discrepancies between the preferable and the planned workforce structure.

Finally, Equation (16) limits, for each period, the labour cost and the outsourced hours cost within the forecasted budget and constraint (17) imposes that the variables are non-negative.

For the case study, the proposed model is solved by means of the optimization software IBM ILOG CPLEX Optimization Studio 12.6.0.0 version. Even if the model has a high number of variables (21871 real variables; 21500 integer variables; 5843 binary variables) and constraints (54862), optimal solutions are obtained in reasonable solving times (less than half an hour which, considering the kind of problem being solved, it can be considered insignificant).

4. Case study. Once seen that to fulfill the objectives on the staff evolution a MILP may be useful, we provide an example to observe the relation between the strategic view of the staff pyramid and the necessary economic resources, while considering other aspects, such as the service level or the accomplishment of an ideal pyramid for ensuring the three academic missions (teaching, research and technology transfer). This case study is designed and presented in this section. The main goal is to evaluate the performance of the model proposed in Section 3. The results will also be used to explore the relationship between required economic resources required to help workers' promotion and the preferable staff composition pursued, altogether answering the objectives of the paper.

Numerical results and corresponding analysis are presented in Section 6, while Section 5 introduces the considered preferable workforce compositions chased and scenarios for evaluation.

As previously mentioned, workers are distributed between temporary and permanent categories. Temporary categories are characterized by holding workers with low capacity. Their work contracts are yearly renewed; otherwise, workers lose their job. Being renewed, workers are automatically promoted to a higher category. Hereinafter, temporary categories are labeled by KT .

On the other hand, permanent categories are characterized by holding workers with high capacity. Workers can follow two different career pathways: contractual (KC) and public/tenure ones (KP). For strategic decisions the main difference between them is that only workers following contractual pathway can be fired, provided economic compensation *cf* though. Currently, in public HEIs, there is a total of 15 categories (at each unit or department): 8 in the subset KT (5 per each year as an Assistant Lecturer and 3 per each year in the Tenure-Track Lecturer category), 3 correspond to subset KC (2 within the Tenured Assistant category - i.e. College or University - and 1 within the Full Professor category) and 4 are within subset KP (2 categories within the Tenured Professor category - i.e. College or University - and 2 within the Full Professor category - i.e. College or University -).

For modeling purposes, several data are needed (see Section 2), whose sources are listed in the following:

- Personnel capacity h_{kt} and costs (c_{kt} , v_t) are public information and these are considered constant over the time.
- The required capacity (demand) for each unit C_{ut} is calculated from the number of students for the subjects given by each department of the institution.
- The expected personnel retirements L_{ukt} are calculated from historic data. The same approach is adopted for estimating the minimum required excess of capacity for each category α_{ut} , which is accepted around 15%. This capacity oversizing covers the reduction in the effective workers' capacity for addressing other tasks apart from teaching.
- The sets of categories Γ_k^+ and Γ_k^- derive from the regulatory framework applied to public universities. The budget B_t for the institution is estimated from public information.
- An eight-year horizon is considered adequate for the strategic capacity planning here, since comprising two full legislatures of the rector and institution government team.

Apart from the input data indicated above, further parameters are applied as indicated in the model to achieve preferable workforce composition. These data are listed in the following:

- Bounds UP_{kt} and LP_{kt} for the proportion of each category in the workforce composition are assumed to be around $\Delta\%$ from the defined preferable composition.
- The economic penalty λ_{kt} has been weighted as the annual salary per each category and worker. Also, penalty μ_t is calculated proportionally to the annual average budget per department (i.e. around 5%).
- The value θ_k , which includes additional expenditures for personnel promotions, is assumed to be around 10% of the salary of a worker in a category k , $\forall t$. The relationship between $c_{kt}\theta_k$, $\forall t$, and category is represented in Figure 3. As can be noted, additional resources for training, research, dissemination activities and others, all helping workers to achieve required merits for promoting, increases with worker's salary, so with category. This relationship is

valid for all time periods in the time horizon, since the salary c_{kt} is considered constant. The relationship between promotion expenditures and category results totally inversed in Figure 4, referring the expenditures to workers' capacity. As can be noted, addressing the high capacity of skilled workers, and despite their high salary, relative expenditures for promotion result are lower than for temporary workers.

- The promotional ratio for temporary categories is bounded by $r_{ukt_min} = 0.4$ and $r_{ukt_max} = 1$. For permanent contractual categories, the adopted limits are $r_{ukt_min} = 0.4$ and $r_{ukt_max} = 0.8$. Finally, for permanent public / tenure categories, promotional ratios results bounded by $r_{ukt_min} = 0.2$ and $r_{ukt_max} = 0.8$. These values have been derived from historic data.
- Finally, r_{ukt} can increase or decrease up to 10% yearly, so $|\Delta r| = |r_{ukt} - r_{ukt-1}| \leq 0.1$.

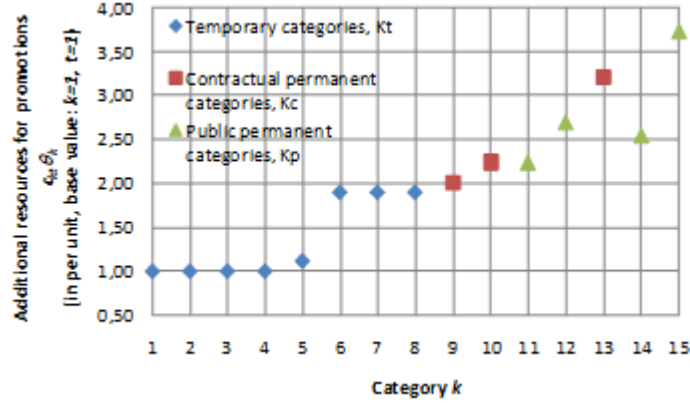


FIGURE 3. Relationship between assumed additional resources for encouraging worker's promotions $c_{kt}\theta_k$ and category k . Values are expressed as relative to $c_{1,1}\theta_1$ (category 1).

According to Figures 3 and 4, it can be observed that the budget allocated to the categories belonging to KT is very different. This is because the capacity of categories Assistant Lecturer and Tenure-Track Lecturer is very different, that is, it is more profitable for the HEI to invest in categories with greater capacity per salary (i.e. Tenure-Track Lecturer), since the demand is measured in teaching needs. However, given the importance of the Assistant Lecturer category for the continuity of the teams and as the basis of the academic career, it is necessary to invest a certain amount of money, which expressed in salary relative terms, is an important investment.

5. Institution models and scenarios for analysis.

5.1. Institution models. The different strategic views of the institution lead to adopt a variety of ideal institution models (i.e. different preferable workforce compositions). In this paper, we consider 3 preferable institution models, which have been derived from the results of a poll (the questionnaire has been summarized in the Appendix), specifically addressed to a group of relevant and experienced academics. The three institution models are introduced in the following.

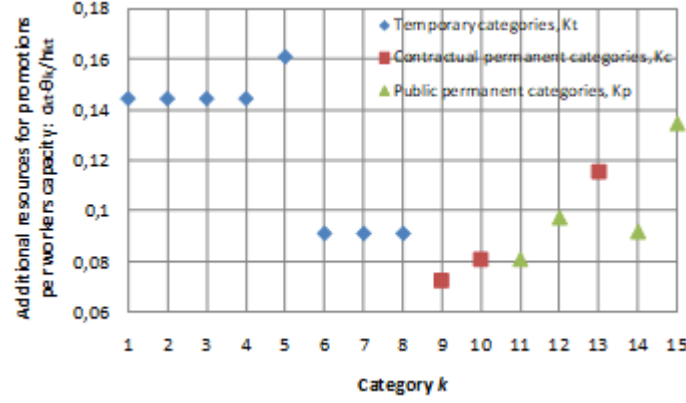


FIGURE 4. Relationship between assumed additional resources for encouraging worker's promotions and category, expressed as relative to workers' capacity.

- **Model A.** This model considers that the institution should create knowledge, not only to ensure the sustainability of the organization, but also to feed other sectors of the society. Thus, the academic structure is mainly based on the training of a large number of young assistant professors and PhD students. This configures a workforce pyramid with important share in personnel within KT . Young professionals within these categories have a high rotation rate and a low teaching capacity, so this envisages a workforce composed by a higher number of workers than in the case of prioritizing experienced academics within permanent categories.
- **Model B.** Slightly decreasing the share of workers in KT , this model considers that the young researchers in the workforce pyramid should be large enough to just ensure future sustainability of the organization, but no more (e.g. other institutions or the industry). This means that young researchers will cover personnel generational replacement needs, and also retain the knowledge created in the institution. To do this, it is particularly necessary to develop mentoring programs for PhD students and professor assistants.
- **Model C.** Finally, further decreasing the share of workers in KT , this model proposes to configure a high experienced institution workforce. This vision is adopted considering that the high capacity of experienced academic personnel could diminish the total workforce size and cost. One drawback of this model is the scarcity of young researchers in KT because the generational replacement could be compromised and/or satisfied by just hiring workers from labor market.

The results of the poll yielding all three institution models are presented in Table 2. As can be noted, for all institution models, the desired share in categories within KC is almost the same. This is because usually workers aim to access to these categories just in order to achieve the academic merits and finally obtain a contract in KP (permanent tenure pathway).

Table 2 Preferable workforce compositions for institution models A, B and C.

	Model A	Model B	Model C
Proportion of workers in KT	42%	34%	27%
Proportion of workers in KC	17%	18%	16%
Proportion of workers in KP	41%	48%	57%

As can be noted in Table 2, the share of personnel within KT progressively decreases from model A to model C, in charge of progressively increasing the share in KP . According to the results of the poll, the share of personnel within KC remains almost unalterable for all institution models. This reflects the preference of experienced workers to follow the public / tenure pathway rather than the contractual pathway.

While Table 2 shows the mean values, considering that the standard deviation from the results of the poll is closed to 25%, the parameter Δ defined in Section 4 is considered 25%.

Finally, just remark that in spite of considering all 42 units or departments, the most detailed analysis is performed around three representative departments. These departments hold the average capacity for all departments. Further, their initial workforce composition matches with the ideal or preferable institution models A, B and C respectively. The reduced size of the problem enables the model evaluation in Section 5.3. Also, it is important to note that since no strategic decisions related to interdepartmental personnel transfer are considered and the total budget of the institution is divided among departments, these are viewed by the optimization problem as independent units. This enables us to reduce the analysis to the three equivalent departments, instead of modeling all the 42 departments. Further, matching initial compositions to the models derived from the poll permits to evaluate the obtained results of the optimization problem under different initial workforce compositions.

5.2. Scenarios for evaluation. This section presents several scenarios for analysis, which are mainly characterized by considering different initial and preferable compositions, as well as different temporal trends in demand and available budget, both depicting different academic and personnel policies:

- Initial composition: A / B / C
- Preferable composition: A / B / C
- Demand-Budget: CC / CD / DC / DD / IC / II / ID (C: Constant, D: Decreasing, I: Increasing)

The combination of the above gives up to 63 scenarios, which are summarized in Table 3.

Some scenarios propose a sort of steady state situations, in which neither demand nor available budget vary over time, and even preferable composition matches with the initial one. Their results in such circumstances can be intended as references or base cases. On the other hand, scenarios in which demand progressively increases over time, while available budget remains constant add difficulty to the determination of staff planning. For such scenarios it is very interesting to evaluate in what extent the objective of adopting preferable compositions (and personnel promotions) are sacrificed to prioritize economic resources. Scenarios characterized by a decreasing or constant demand and an increasing trend for budget are left out of discussion, because an excessive budget would not have a great influence in the strategic capacity planning for the institution.

Table 3 List of scenarios for analysis.

Sc.	Initial comp.	Pref. comp.	Dem.- Budget	Sc.	Initial comp.	Pref. comp.	Dem.- Budget	Sc.	Initial comp.	Pref. comp.	Dem.- Budget
1	A	A	CC	22	A	B	CC	43	A	C	CC
2	A	A	CD	23	A	B	CD	44	A	C	CD
3	A	A	DC	24	A	B	DC	45	A	C	DC
4	A	A	DD	25	A	B	DD	46	A	C	DD
5	A	A	IC	26	A	B	IC	47	A	C	IC
6	A	A	II	27	A	B	II	48	A	C	II
7	A	A	ID	28	A	B	ID	49	A	C	ID
8	B	A	CC	29	B	B	CC	50	B	C	CC
9	B	A	CD	30	B	B	CD	51	B	C	CD
10	B	A	DC	31	B	B	DC	52	B	C	DC
11	B	A	DD	32	B	B	DD	53	B	C	DD
12	B	A	IC	33	B	B	IC	54	B	C	IC
13	B	A	II	34	B	B	II	55	B	C	II
14	B	A	ID	35	B	B	ID	56	B	C	ID
15	C	A	CC	36	C	B	CC	57	C	C	CC
16	C	A	CD	37	C	B	CD	58	C	C	CD
17	C	A	DC	38	C	B	DC	59	C	C	DC
18	C	A	DD	39	C	B	DD	60	C	C	DD
19	C	A	IC	40	C	B	IC	61	C	C	IC
20	C	A	II	41	C	B	II	62	C	C	II
21	C	A	ID	42	C	B	ID	63	C	C	ID

6. Analysis of the results. This section discusses around the computational results obtained in each of the considered scenarios, as presented above. The results are evaluated through metrics to test the adjustment of the achieved workforce composition to the preferable one, as well as the promotional ratio and the associated additional expenditures for workers' promotion. The following subsections deal with these numbers in a succinct and organized manner. Previously, though, different numerical metrics are formulated, for the results evaluation.

6.1. Formulation of numerical metrics. Metric R computes the total additional costs for the considered time horizon for personnel promotion. This metric is defined as:

$$R = \sum_{\forall u} \sum_{\forall k} \sum_{\forall t} \theta_k \cdot c_{ukt} \cdot (r_{ukt} - r_{ukt_min}), \forall t \quad (18)$$

Metric RC_{ukt} is the proportion of staff in category k over the whole staff of the unit u at period t . This is expressed in per unit by:

$$RC_{ukt} = \frac{w_{ukt}}{\sum_1^K w_{ukt}}, \forall u, k, t \quad (19)$$

RC_{ukt} , the obtained workforce composition per unit, category and time, can be compared to the preferable weight or proportion of staff in the whole institution for each category PC_k , yielding the cumulative "Global Discrepancy" GD_{ut} per each unit and time, which is computed as:

$$GD_{ut} = \sum_1^K |PC_k - RC_{ukt}|, \forall u, t \quad (20)$$

The global discrepancy GD_{ut} is expressed in per unit values (p.u.). Note that since it accumulates the discrepancy associated to each category, the obtained value can exceed 1 p.u. (i.e 100%).

6.2. Evaluation of workforce composition. This section evaluates the results for all 63 computational scenarios (see Table 3) in terms of the adjustment of workforce composition to the preferable one, i.e. using Global Discrepancy GD_{ut} .

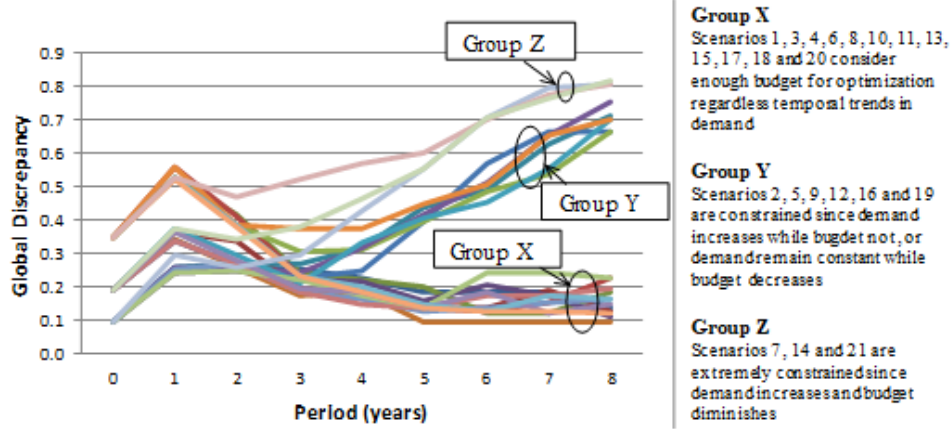


FIGURE 5. Global discrepancy for scenarios 1 to 21 (so considering the institution model A as the preferable composition), considering different initial compositions as well as different temporal trends in budget and demand.

Scenarios 1 to 21 (Figure 5) can be arranged in three main groups, addressing the evolution of global discrepancy. Those scenarios steadying global discrepancy at the end of the considered time horizon are included in the Group X. In such scenarios there is enough budget for optimization regardless temporal trends in demand. For instance, in the scenario 1, neither available budget nor demand vary over time, yielding enough economic resources for workforce optimization, in regard of the achievement of a preferable structure. Another example for Group X is the scenario 13, considering increasing temporal trends (around 1.5% per year) for both demand and available budget. Under these circumstances, the institution also has enough economic resources, thus adjusting workforce composition to a preferable one.

Scenarios not included in Group X have been classified in Groups Y and Z. Those included in Group Y are characterized by a progressive decrement in economic resources with respect to demand, which constrains the achievement of a preferable composition. This yields a progressive increment in global discrepancy, which is directly related to the aforementioned progressive decrement in economic resources. For instance, scenario 2, concerns a linear and yearly decrement of about 1.5% in budget, while demand remains constant. Thus, the achievement of a preferable composition is progressively sacrificed to prioritize economic resources to maintain the necessary personnel for teaching. Further exacerbating this progressive mismatch between available budget and demand, the results for scenarios in Group Z depict even higher global discrepancies.

Finally, just note that the considered initial composition for all scenarios in Figure 5 can be identified by the initial global discrepancies (year 0). As can be observed, for those scenarios considering an initial workforce composition which can be resembled to that for institution model A, the initial global discrepancy is minimum (around 0.1). Similarly, for those concerning an initial composition most resembling to model B, the initial global discrepancy is sensibly higher (around 0.2). Finally, major initial global discrepancies are intended for those scenarios concerning initial composition similar to institution model C.

Similar trends in global discrepancy are observed for scenarios pursuing preferable workforce composition for institution models B and C, as depicted in Figures 6 and 7, respectively. Note that analogously to the classification in the Groups X, Y and Z of scenarios with institution model A, scenarios pursuing institution model B (Figure 6) are classified in Groups R, S and T, and scenarios pursuing institution model C are divided into Groups U, V and W (Figure 7).

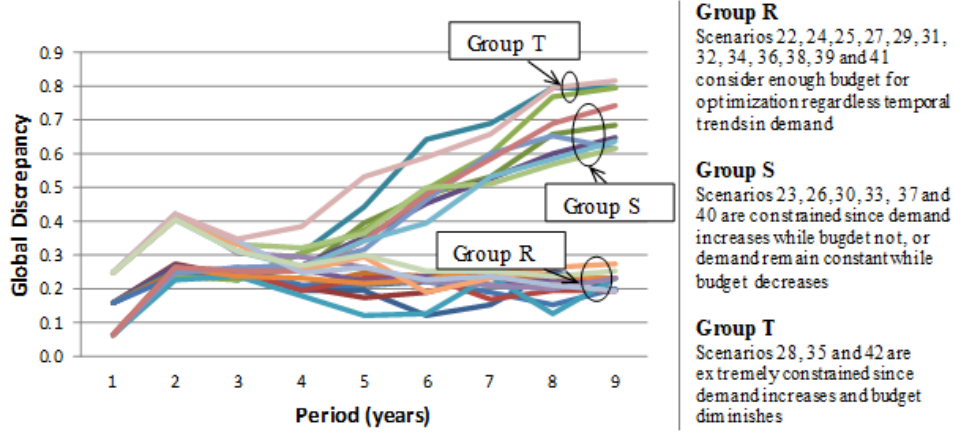


FIGURE 6. Global discrepancy for scenarios 22 to 42 (so considering the institution model B as the preferable composition), considering different initial compositions as well as different temporal trends in budget and demand.

The benefits from controlling the promotion ratios can be seen comparing the results for the Global Discrepancy in [10] and this paper. In the former, the proportion of workers in the unit u that can promote is a maximum established value. There, the Global Discrepancy takes values around 0.3. In this paper, where the proportion is variable, the reference scenarios are 1, 22 and 43 (depending on the preferable composition A, B or C). Their results are considered respectively in Groups X, R and U. In the first of them, Global Discrepancy has values between 0.1 and 0.2 and in the other two, around 0.25.

Deeping further in the evaluation of the obtained results, Figure 8 contributes to the understanding of the above global discrepancies. Again, and for the sake of clarity, results are aggregated in terms of the yet identified groups of scenarios. In particular, now analysis compares the obtained workforce pyramids at the end of the considered time horizon and the preferable compositions pursuing institution models A, B and C.

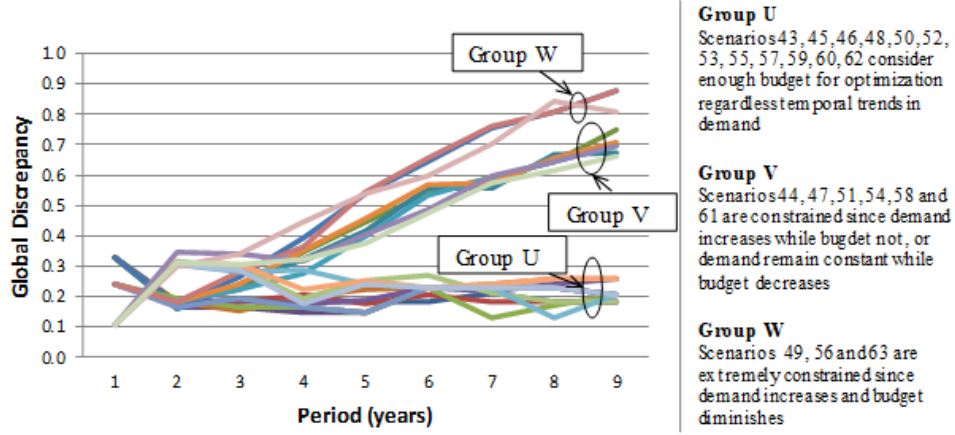


FIGURE 7. Global discrepancy for scenarios 43 to 63 (so considering the institution model C as the preferable composition), considering different initial compositions as well as different temporal trends in budget and demand.

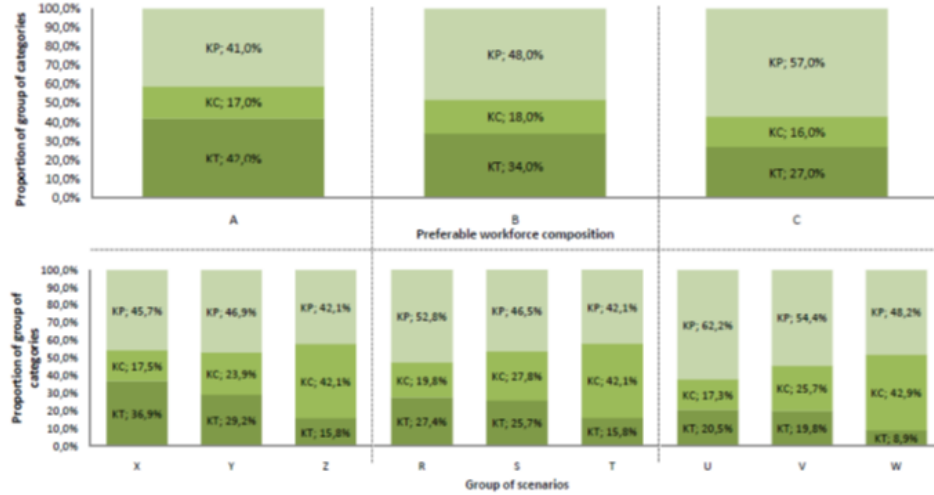


FIGURE 8. Comparison between the achieved workforce composition per group of scenarios and the initial workforce structures per categories, while pursuing institution models A, B and C. The initial number of workers adopting institution models A, B and C are included in parenthesis.

As can be observed in Figure 8, the achieved workforce pyramids for Groups X, R and U are similar to their corresponding reference models, A, B and C. As a reminder, scenarios in Groups X, R and U are characterized by concerning enough economic resources regardless temporal trends in demand. For these groups of scenarios, it is interesting to note that the achieved workforce pyramids at the end of the time horizon do not match exactly with preferred compositions. For instance,

despite the fact that the initial workforce compositions in scenarios within Group X most resemble to that concerning institution model A, the optimization problem tends to slightly modify staff composition increasing the weight of categories within KP , at the sacrifice of the capacity hold by categories within KT . The same behavior can be observed for the pair of Group R and Group U. These deviations are result of the proposed optimization model for staff planning, which permits deviating categories' size up to $\pm 25\%$ from their preferable weight without penalization. Thus, the solution uses this flexibility to slightly increase the proportion of high skilled workers within KP , as their cost per capacity unit is lower than for personnel within KT . Normally, the size of each of the categories for a department of the institution hardly reach few tens of workers, so one single worker may represent an important percentage of total category size. Thus, the above mentioned admissible deviation of 25%, at the end, could represent just few workers and so this is considered to be realistic for the purposes of the paper.

Another interesting conclusion, comparing the achieved workforce structures in Groups X to Z, R to T and U to W, is that the more constrained the budget with respect to demand is, the more the weight for categories within KC is. For instance, scenarios within Group Z are quite constrained in budget with respect to demand profiles, and the proportion of expensive personnel -in terms of cost per working capacity unit- is greatly reduced overweighting categories within KC , which hold low cost personnel in relation to their working capacity. The deviations between the weight of categories within KC and KT from preferable weights are the main contributors to global discrepancy, as depicted in Figures 5, 6 and 7.

6.3. Discussion around promotional ratios. Section 6.2 discusses the obtained results for each of the considered 63 computational scenarios in terms of adjustment of workforce composition to a preferable one. Such adjustment or modulation of workforce composition is enabled and governed by policies on personnel promotions. Accordingly, this last subsection discusses how policies on personnel promotions should be adapted to the particularities of each scenario, so as to achieve an optimized staff planning.

In this regard, Figure 9 depicts the average promotional ratio for personnel in KT and KC , under the conditions of all computational scenarios and for the considered time horizon. As can be observed, the average promotional ratios for categories within KT progressively decreases from those obtained in scenarios within Groups X, R and U, to those achieved in scenarios in Groups Z, T and W, respectively. Conversely, promotional ratios for personnel within KC slightly increase. These trends are aligned to the conclusions achieved in Section 6.2: the number of workers building up personnel within KC increases combined with a reduction in personnel within temporary categories KT , under scenarios constrained in economic resources with respect to demand.

In addition, it is important to note that for all considered scenarios -economically constrained or not with respect to demand-, the optimal staff planning determines promotional ratios for both KT and KC higher than the defined minimum levels r_{ukt_min} . This implies to incur in additional expenditures (training, dissemination activities and others) for personnel promotion. Note that for categories within KT , the minimum and maximum promotional ratios are set to $r_{ukt_min} = 0.4$ and $r_{ukt_max} = 1$. For permanent contractual categories, the adopted limits are $r_{ukt_min} = 0.4$ and $r_{ukt_max} = 0.8$.

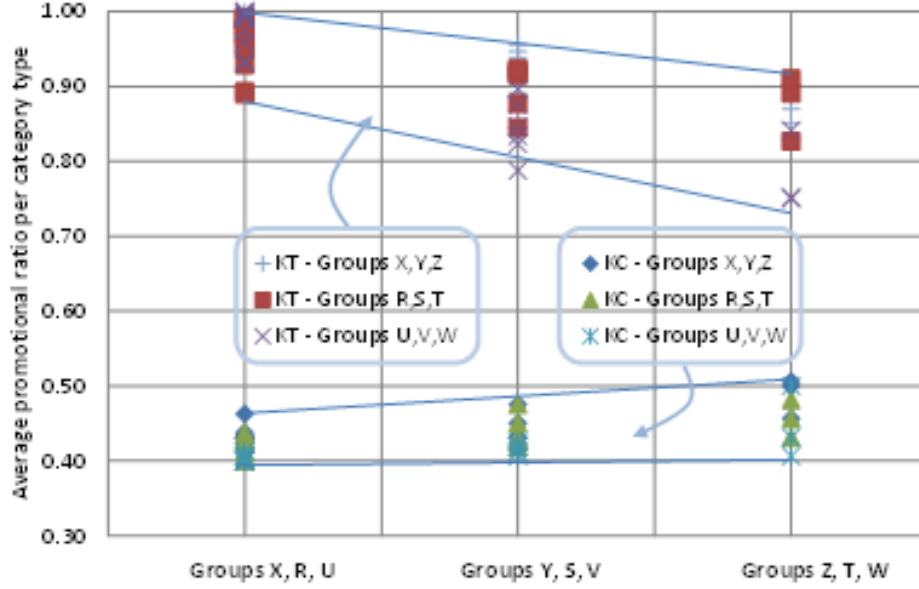


FIGURE 9. Average promotional ratio for personnel within *KT* and *KC*, under the conditions of all the scenarios.

The above decrement in promotional ratio for *KT* greatly affects the total number of promotions for the time horizon, as depicted in Figure 10. Indeed, the number of promotions decreases from nearly 120 (in average, for scenarios in Group X) to 80 (in average, for scenarios in Group Z), so around 40% less. Lower decrements, around 30%, can be observed comparing the number of promotions for scenarios in Group R to those in Group T; and around 28%, comparing scenarios in Group U to those in Group W.

So, the decrement in the total number of promotions depicted in Figure 10 envisages also a decrement in additional expenditures incurred for such purpose. This can be clearly observed in Figure 11, which presents the total cost for personnel promotions for the considered time horizon and all the scenarios. For the sake of clarity, results for Groups Y and Z, S and T, and V and W, are expressed as relative to the average cost in Groups X, R and U respectively.

As can be observed, the additional expenditures for personnel promotion decay in scenarios constrained by economic resources with respect to demand. For scenarios pursuing the institution model A, i.e. those in Groups X, Y and Z, additional expenditures for personnel promotion in Groups Y and Z decay down to 10% in average, with respect to additional expenditures envisaged for scenarios in Group X. Similarly, for scenarios pursuing a staff composition according to institution model B (Groups R, S and T), the above mentioned reduction results around 5%.

In addition, the reduction in additional economic resources for promotion is clearly exacerbated in Groups V and W, with respect to those contemplated for scenarios in Group U (i.e. a staff composition according to that specified for institution model C). As indicated in Figure 8, the preferable weight for personnel within *KT* in institution model C is the lowest amongst all three considered institution

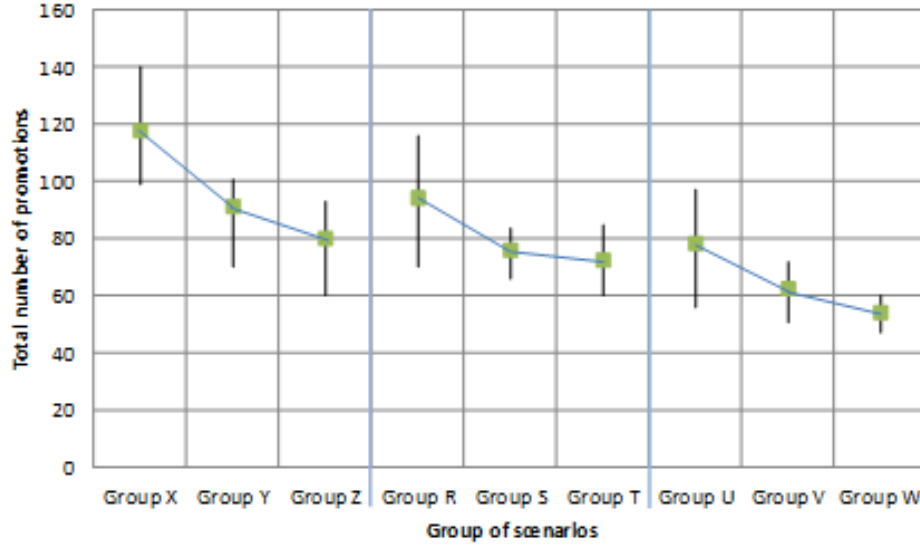


FIGURE 10. Total number of promotions for all groups of scenarios and for the considered time horizon.

models. Thus, in the case of economic restrictions in relation to demand (scenarios in Groups V and W), the results for staff planning exacerbate the replacement of personnel within KT by high skilled personnel in KC . Altogether is translated in a decrement of nearly 30% in average for additional expenditures for promotions in scenarios in Group W with respect to those in Group U.

7. Conclusions. This paper addresses the strategic staff planning problem in public HEI, taking into account several specific restrictions such as hiring, firing and worker's promotion rules, as well as workforce heterogeneity. The optimization criterion for staff planning is not only based on purely economic metrics, but also includes adoption of a preferable staff composition and the service level. The strategic planning is formulated as a Mixed Integer Linear Programming model.

Amongst the different strategic decisions (i.e. hiring, firing and promotions), this paper is also concerned with finding the relationship between the economic resources for workers' promotion and the preferable staff composition pursued in strategic staff planning. To this aim, several computational scenarios are evaluated, concerning different initial and preferable workforce structures, i.e. different institution models, and different temporal trends in budget and demand. It is depicted in terms of the discrepancy between the achieved workforce composition and the preferable one at the end of the time horizon for analysis. The 63 scenarios are classified into three main categories:

- The first one, Groups X, R and U, are characterized by enough budget, regardless temporal trends in demand. This permitted to maintain the global discrepancy over time stable. For these scenarios, the optimization model succeeds in determining a workforce structure adjusted to the preferable one.
- Conversely, the second and third ones, including Groups Y and Z, S and T and V and W, are characterized by a constrained budget with respect to temporal

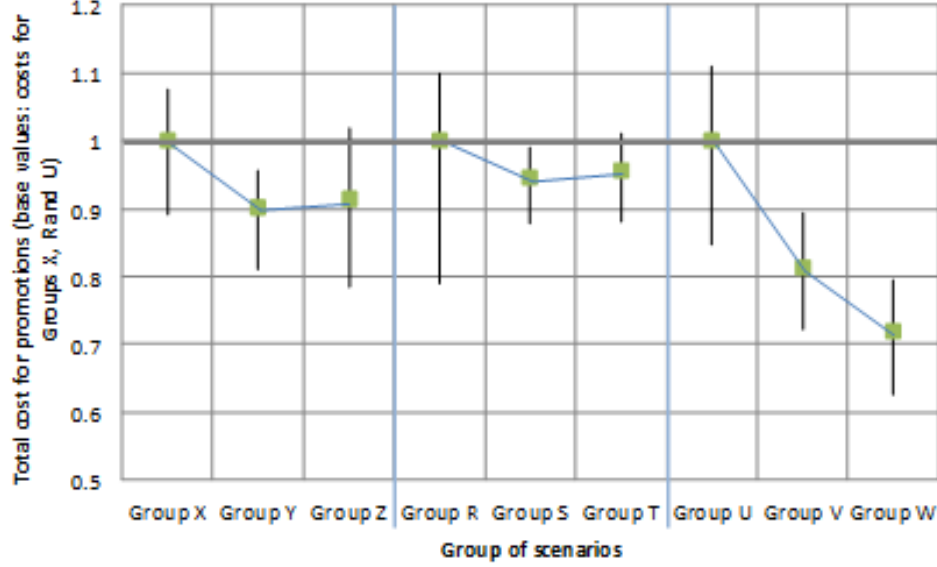


FIGURE 11. Total cost incurred for personnel promotions (during the time horizon and for all the scenarios), expressed as relative to the average cost in scenarios within Groups X, R and U.

trends in demand. For such scenarios, metric global discrepancy increases over time, weighting the extent to which the workforce composition deviates from the preferable one. For these scenarios, the institution model pursued does not matter, to some extent, to prioritize economic resources to maintain the strictly necessary personnel to front teaching demand. In practice, this is translated into an increase in highly skilled workers at the sacrifice of young researchers in temporary categories. This happens because skilled workers, according to the adopted cost data, offer better working capacity with respect to their cost than young researchers. For instance, and as presented in Figure 8, the number of workers in categories within *KT* in Group X is 16 and results decreased to 6 in Group Z. This decrement of temporal workers is accompanied by an increment in workers under *KC* and *KP* from 27 in Group X to 32 in Group Z.

The obtained results in terms of global discrepancy are aligned with those specifically addressing workers' promotion in Section 6.3. Altogether serve to ensure that policies on personnel promotions should be adapted to the particularities of each scenario, i.e. temporal trends in budget and demand, so as to achieve the optimization of staff planning. In particular, results depicted that promotional ratios for young researchers within temporary categories decrease under scenarios constrained in budget with respect to temporal trends in demand. Conversely, and under such circumstances, promotional ratios for high skilled personnel within permanent categories are slightly increased. In any case though, for all scenarios, promotional ratios for young researchers result between 75% and 100%. For permanent workers in categories within *KC*, promotional ratios hardly exceed 50% at the maximum.

In terms of total promotions, and comparing scenarios constrained and not constrained in budget with respect to demand, the number decreased between 28% and 40%, depending on the pursued institution model and initial workforce composition. This reduction in the number of promoted workers is directly translated into a reduction in additional expenditures to be envisaged for such purpose. In particular, expenditures for personnel promotions are reduced down to 10% and 5% in average for those scenarios pursuing the institution models A and B respectively, and reached the 30% for those scenarios pursuing institution model C.

The proposed model can be used to determine the size and composition of workforce in HEI, considering budget constraints as well as workforce heterogeneity (workforce expertise and category). At the end, this model can be translated into a practical tool for decision making process in strategic personnel planning not only for HEI, but also for other knowledge intensive organizations due to the proposed general formulation and the different scenarios considered.

The main limitation of the model is that in the strategic planning some data are examined in an aggregate way (in the study case, the workers are not treated individually), although this fact does not invalidate the results, it could happen that the obtained results were not completely accurate, so a detailed analysis should be done.

Possible further research could consist in adding uncertainty to the required capacity (demand), by considering different scenarios; in the probability that a member of the academic staff is able to progress to another category; or in the available budget. Stochastic models and simulation may be used (or combined) depending on the case. Also, the model could be adapted to other service organizations as, for instance, research centers or hospitals.

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Appendix: Poll to establish the preferable composition models. We are conducting a research project on the planning of the academic staff at the university in the long term. One of the criteria we use for planning is the composition of the staff (percentage of academic staff belonging to the different categories), so that it is close to what could be considered ideal. Naturally the ideal composition depends on the type of university and context, the strategic objectives of the university and the conception of how the university should be (i.e. tasks related to teaching, research, technology transfer and management). Therefore, we ask your collaboration to define this ideal composition (or one of the possibilities). The ideal composition will be based on the percentage of members in each of the main categories in a university. The percentages must add 100.

1. Percentage of University Full Professors within the total staff in University.
2. Percentage of University Tenured Professor and Tenured Assistant Professor within the total staff in University.
3. Percentage of University Tenured- Track Lecturer within the total staff in University.
4. Percentage of Assistant Lecturer within the total staff in University.

The results obtained were very different, according to the experts' view, the preferable composition resulted in (on average) three different ideals (models A, B and C).

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E-mail address: maria.rocio.de.torre@upc.edu

E-mail address: amaia.lusa@upc.edu

E-mail address: manel.mateo@upc.edu

E-mail address: ElHoussaine.Aghezzaf@UGent.be